TECHNOLOGICAL ADVANCES IN THE ART AND SCIENCE OF TEACHING

Interactive Computer Simulators for Business and Management Courses

by

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ABSTRACT

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Melvin J. Anderson, Ph.D. May 1997

This paper examines the use of interactive computer simulators as teaching tools for business and management courses in higher education. It observes that many recent innovations in classroom teaching are mostly one-way communications which do not strongly encourage active student participation in the discovery and invention of knowledge. Although classroom technology has progressed from high school "film strip hour" to present-day overhead projectors, videos and distance learning tools, too little has been done to create a truly interactive learning environment. Attractive color slides and interesting videos seldom give students an opportunity to develop and test theories and processes in dynamic simulations that provide a "virtual reality" for learning how complex systems function.

In today's competitive educational environment, colleges are under attack from "electronic education" firms offering training programs via cable television, internet and video tapes. These media are becoming more and more affordable, while higher education's tuition is increasing. And while colleges are responding to these challenges with distance learning tools and a variety of new devices that enhance lecture presentations, none of these offers much beyond static, one-way presentations that cannot respond to student inputs or assess their understanding. If the opinion of an expert has merit, then higher education ought to listen to the warnings of people like Peter Drucker, who predicts that with higher education's uncontrollable expenditures and without any visible improvement in content or quality, the system is rapidly becoming untenable.

The paper identifies a variety of new learning tools that can visibly improve course content and quality in a number of academic disciplines. Interactive simulation software programs for college courses are being offered by several software producers and industrial education organizations. These simulator programs can be run on existing personal computers, but they are not simple video games. They provide dynamic simulations of real-world organizations that students can run, change parameters, measurements and policies, and observe the effects of their decisions on a system's performance. With an instructor guiding them, students can discover (or invent) better methods for management and develop a better view of the need for whole-system solutions that identify real causes and effects, and focus on the critical factors in complex systems.

Presentation of this paper would include a ten-minute on-screen demonstration of a selected interactive management simulator provided by one of the producers of such programs. The demonstration easily shows the remarkable versatility of interactive simulators in teaching logistics, marketing, distribution, production, operations research and other management disciplines. Balanced with appropriate overhead slides, lectures and discussions, interactive simulators offer educators a dynamic teaching tool for making college courses relevant to the needs of students and their employers. In a formal academic environment, these tools represent a new opportunity for keeping higher education competitive with other instructional media.

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TECHNOLOGY IN THE CLASSROOM: AN EMERGING RESOURCE

Many of today's college classrooms are showplaces for impressive audiovisual equipment. Video projectors, large-screen television sets with video cassette recorders and a variety of optical projectors enable professors to add dazzling course materials to otherwise ho-hum topics. Where professors once labored with chalk on chalkboard, they now display beautiful full-color slides from an overhead projector, television projector or monitor.

Versatile computer software programs like Microsoft's Power Point make creating these works of art very easy. Colorful slide shows that dazzle students are easily produced on a personal computer and printer. Lectures of this caliber provide a smooth flow of information, good visual images for retention and a high degree of confidence in the credibility of the teacher's subject knowledge. Well-prepared slides help teachers avoid inconsistencies while reducing the likelihood of misconceptions and unnecessary, time-consuming reiterations. Moreover, the students are likely to be significantly more confident that the courses and degree programs they're pursuing reflect state-of-the-art thinking on whatever topics are addressed. In short, good audiovisuals mean good student acceptance of the concepts presented--a genuine blessing for most teachers. Unfortunately, pretty slides do not automatically generate classroom discussion.

FILM STRIP HOUR: THE WAY IT WAS

Most of us remember "film strip hour" from our high school days; somehow this usually happened on Friday afternoons. The lights dimmed and we sat quietly at our desks watching a series of projected images from a small projector into which the teacher inserted 35mm film strips. Some of these devices included tape or cassette players that added audio to the slides.

Teachers loved film strip hour; they didn't have to do much work. Principals also loved it; they could tout their schools' participation in "high-tech" learning. School boards liked film strips because they were inexpensive, and parents were happy because they knew their children were getting state-of-the-art education. Most of all, the students liked film strip hour because they didn't have to think. Nobody questioned the accuracy or currency of the material on the film strips, and everybody like the way the students quietly accepted it.

A slightly different "high-tech" evolution has occurred in higher education. Boxes of overhead slides accompanied new textbooks, and 16mm movies purchased from a number of educational film firms were often added to courses. But the state of the art continued to move forward. Video tapes began replacing films and overhead projectors became permanent fixtures at the front center of the class room; white boards and dry-erase markers began replacing the messy chalk boards. Professors occasionally "downloaded" interesting programs from educational TV channels (not always with permission) to show in class, while universities acquired legitimate libraries of video tapes for almost every discipline. A teacher could carry an entire course in one briefcase--a stack of well-made overhead slides and a handful of video tapes. Lecture notes became less and less important as professors developed better and better slides from which to present course material; in some cases, the need for written notes was all but eliminated by a combined set of published slides from the textbook company plus those made by the professor hemself.

THE NEW ACADEMIA: GOOD NEWS AND BAD NEWS

These new tools made academic life more predictable, better planned, and much more controllable. Professors began building entire courses around collections of overhead slides, and they also saw the importance of periodically updating their collections with new slides and adjusting the material to enhance student acceptance and minimize negative feedback. In the ultimate perfection of these tools, a professor can deliver a seamless presentation that introduces, presents and reviews the topic material flawlessly--in living color. Awesome . . . or is it?

Unfortunately, higher education is under serious attack from a variety of external and internal forces. Education is a free-market commodity, and a large number of electronic education firms are now offering a large number of training and educational courses via cable television, the internet and video tapes to persons who can view and re-view these programs in their homes and offices. A new attitude has begun to emerge, especially among businesses who want their employees to possess very current knowledge and skills pertaining to their jobs.

The "electronic classroom" presents a viable alternative to formal higher education for satisfying some learning needs. It is perceived by some as informationally more current than the politically-correct, good-old-boy college classroom-teacher environment. On-screen learning is certainly more flexible in schedule and affordable in price than most college offerings. Moreover, viewers can replay video tapes until they learn the material therein, and then pass them on to others with no additional cost. These are truly formidable threats to the once-unassailable college education.

At the same time, higher education is not unaware of these environmental changes. Many schools now provide extensive off-campus networks of smaller learning centers, capable of bringing formal higher education to more people in more places than ever before. Distance learning tools and techniques are being employed to extend these networks to even more remote locations via two-way video conferencing. Computer-generated slides and spreadsheet programs transmitted to distance learning sites give the professor additional versatility. Some schools have even joined the electronic classroom wave by making video tapes of on-campus lectures and sending them to outreach centers and individual students via satellite or post office. Academia is no stranger to the "information superhighway." Large-screen overhead slide shows are still popular, particulary in "megasection" courses delivered in large campus auditoriums by one professor lecturing to several hundred students at one time. The economic benefits of this approach are obvious.

HIGH-TECH ONE-WAY COMMUNICATION

All of these techniques have one thing in common. Pretty overhead slides, video tapes and television monitors all tend to be one-way communication methods. Video tape courses are versatile, but they do not listen to students' inputs and they cannot provide professors with a face-to-face meeting with their students in which they can evaluate students' responses or identify a confused look in their eyes. There is no way for a video tape to lead a student to the discovery or invention of knowledge through a series of Socratic questions and responses. Tapes may be good training tools, but they don't educate. They don't measure student response; they don't even ask.

In megasection courses, there is no time for individual questions and little opportunity for the professor to employ Socratic teaching methods. With hundreds of faces in the crowd, it's hard to read individual expressions or determine if messages are being received, much less understood. Because of the large number of students in these sections, audiovisuals often provide the core material for these presentations. And when student teachers are employed, the focus is almost entirely on the audiovisual materials.

In distance learning applications, the same thing can happen. The hardware for this approach is still evolving, and currently affordable methods provide somewhat limited picture quality and size. Either the professor cannot see the students closely enough to really interact, or there are too many students to provide much one-on-one interaction. Distance learning certainly makes higher education available to more people at an affordable price, and talented educators can turn these sessions into excellent learning experiences. But there is always the need to ensure that the technology is not used as a substitute for the teacher, and that its limitations are seriously considered when course materials are developed.

Textbooks are also part of the problem. The American textbook system is sadly lacking in currency, mostly due to the review and adoption method used by most publishers. Even those texts that come with computer diskettes attached only permit the student to "plug in" data from problems in the book and extrapolate values for specific dependent variables. Many of these programs are merely substitutions for doing arithmetic, providing only static models of simplistic solutions to problems. Few, if any, provide dynamic interaction with system/problem parameters.

Many academic disciplines employ textbooks that use the "case study method" for analyzing problems; this is particularly popular in business school texts. ("Case study," in this context, is not the same as it is used in law schools to examine past legal cases.) The theory behind using this method is that students will inductively uncover profound general theory by solving specific problems. There is another theory, however, that strongly discredits inductive reasoning as a useful source of general knowledge, asserting that although it has an air of credibility, it lacks sound logic and fails to prove causality in most cases. Most academic research, on the other hand, employs deductive reasoning; hypotheses are established and then tested in specific situations to arrive at conclusions that are based on true effect-cause-effect logic or at least some statistical inference that suggests additional research. Most research involves both inductive and deductive reasoning, but without cause-and-effect logic, flow is mostly in one direction.

MORE CLASSROOM TECHNOLOGY

Meanwhile, back at the campus, new audiovisual enhancements continue to emerge. New-technology video projectors enable professors to display large-screen images of detailed computer software and data. Whereas conventional television formats are unable to display the fine detail and small lettering of most software programs, these new devices can easily project 80-character lines sharply onto large screens. Programs such as Power Point, limited to large lettering and simple artwork when used on standard format TV screens, can then be used for very thorough presentations of spread sheet programs and detailed graphics. These new projectors are fairly expensive, but many colleges are redesigning their classrooms to provide them.

But there is still a catch. Unfortunately, the enhancements provided by these devices seldom include interactive course materials. While they enhance the professor's lectures, they also increase the risk that these lectures will become nothing more than "film strip hour."

THE PROBLEM IS STILL GROWING

Let's summarize the above discussion on what's happening and what's not happening in higher education, plus what's happening outside higher education that affects higher education. First, we know that among other things, the "electronic classroom" is drawing some enrollments away from the traditional university. These offerings are often cheaper, more flexible and informationally more current than what academia provides. But they are mostly one-way communication that is at best a training technique.

Second, we know that despite technological advances in the art and science of teaching, many high-tech teaching tools are not interactive. The slides and video tapes are very well done; so well, in fact, they discourage discussion. When students view these masterpieces of computer graphics and cinematography, they can be so overwhelmed by the artfulness and thoroughness that they may regard questions or alternative views as reflections of poor attentiveness or inability to comprehend the contents. This nonresponse, as we have noted, is often interpreted by the professor as understanding and agreement. Good slides are evaluated as good lecture.

We have also become increasingly aware of the limited value of the "case study method" of teaching in academia. Except for legal studies, solving cases derived from compressed actual or fictitious situations seldom causes students to discover or invent realistic solution methods. Without an adequate intuitive knowledge base about a particular situation, without any personal concern for the success of the system being examined in the case, and also without any accountability for the results of the solutions developed, students faced with "two new jobs (cases) each week" quickly learn to adapt their analyses to what they think the professor wants to hear. At this, students become very adept and very convincing.

Finally, we know that students and their employers are increasingly aware of the fact that college degrees do not represent professional skills that graduates can perform on the job. This adds to the growing confidence in electronic education, which is a competitive challenge for higher education. Are there even more serious questions? Are colleges morally and legally responsible for providing students with courses that prepare them for the professions these courses and degree programs claim to teach? Can MBA graduates sue their alma mater for nonperformance when they find out that their degrees are nothing more than certificates? Dr. Eliyahu Goldratt writes in *Critical Chain (1997)*: "I think the major problem is that companies no longer believe that a person finishing an Executive MBA program has become a much better manager due to it."

THE NEED IS STILL GROWING--SCREAMING

All of these conclusions point to a single need that exists within higher education; a need that unless satisfied internally, will lead to a dramatic "crash" in traditional higher education within the next decade.

Peter Drucker, noted management expert and author, is quoted in a *Forbes* Magazine article entitled "Seeing Things as They Really Are" (By Robert Lenzner and Stephen S. Johnson, March 10, 1997), observing that the current setup (in higher education) is doomed:

> Thirty years from now the big university campuses will be relics. Universities won't survive. It's as large a change as when we first got the printed book. Do you realize that the cost of higher education has risen as fast as the cost of health care? And for the middle class family, college education for their children is as much of a necessity as is medical care--without it the kids have no future. Such totally uncontrollable expenditures, without any visible improvement in either the content or the quality of education, means that the system is rapidly becoming untenable. Higher education is in deep crisis."

Crisis means that things will get either much better or much worse. Things will certainly get much different. If higher education is to survive this crisis, it must identify what is really needed for effective change, in order to provide college students with realistic education that prepares them for the professional work they came to college to learn to do. Such educational programs must meed customer (student) demand and:

1. Provide students with a **thinking process** for learning cause-and-effect relationships. Mere correlation is insufficient for business decisions, and no science accepts statistical inference as proof. Logic is as necessary in academia as it is in business or science.

2. Provide students with **interactive tools** that permit varying inputs to models of real-world systems and allow them to experience true output impact. When students learn to measure the impact of varying inputs and "local" decisions on the bottom line of a realistic business model, they will know better how real-world systems work as well. The business world already uses interactive tools to teach its employees how to manage; why not academia?

3. Teach students to examine **complete systems** and determine the constraints and bottlenecks to system performance in dynamic models. Otherwise, they will only learn how to suboptimize the system--diligently improving every part of it under the mistaken notion that this will make the system run optimally.

4. Encourage students to **interact with professors** in the classroom, to ask questions, offer alternative views, and respond to the professors' questions in the discovery and invention of knowledge. Pretty slides and videos do not have to be obstacles to this interaction, provided the professors use them in a balanced, Socratic approach.

FLIGHT TRAINING SIMULATORS

The airline industry and most flying schools, as well as the military services, use very sophisticated simulators to teach flying skills and train pilots in normal and emergency flight procedures. These simulators are remarkably realistic, expensive cockpit mockups with a full set of working controls, displays and instruments that provide every physical and visual sensation of flight. Video systems give the student a forward visual simulation of what would be seen from a real airplane (or nothing, if instrument training is being conducted). All these devices--video, controls, instruments, even sounds--are interconnected through a computer to provide a full-system interactive simulation including full-motion three-axis hydraulically-operated machines that can even simulate air turbulence and induce air sickness and vertigo in a seasoned pilot!

Flight simulators cost a lot less to operate than a Boeing 747. Moreover, emergencies can be programmed into the training sessions without risk of really crashing and burning (but simulated "crashes" can be very dramatic!). They are so realistic in response to pilot controls, that the FAA now allows a major portion of a pilot's upgrade training and evaluation in a new type aircraft to be done in simulators. A pilot who perhaps makes one instrument approach and landing every four flying hours can make four approaches and landings in one simulator hour.

PROFOUND IMPLICATIONS

Simulators involve some very profound implications for experiential learning, because they provide something that even real aerial flight cannot provide: repeatable circumstances. With a simulator, all variables can be held constant except the pilot's judgement and control inputs, permitting a true cause-and-effect analysis of pilot performance without having to assess every factor at one time. The uncertainties of external variation can thus be avoided entirely. Excuses and "choopchiks" (trivialities that detract from the critical) have no place here. This feature involves very profound implications for experiential learning.

THE GENERIC NEED

Eli Schragenheim of Technology Systems Corporation (TSC), a firm specializing in interactive computer simulators, describes the need for management simulators of complex systems:

> Experience is built upon many isolated incidents. We can learn from these isolated incidents to gain a new understanding of the cause-and-effect relationships that exist in our environment. Good managers use insight developed from these experiences to improve their management skills.
>
> On the other hand, the impact of an isolated incident can be misleading. In the uncertain world in which we live, we can easily assign the wrong cause to a specific effect. Since we can rarely make a given situation recur exactly as it did before, it is difficult to distinguish between its random and actual causes. Hence, misinterpretation of a situation is common.
>
> The more complex our environment becomes, the more we need to learn in order to be effective. But the more complex the environment, the more difficult learning becomes. Any new insight that simplifies a complex situation directs us toward the light at the end of the tunnel.

This is especially true in managing aviation/aerospace organizations, where complexity is the name of the game. Schragenheim further describes how interactive simulators provide a way of gaining experience and generating learning of the highest order. Simulators are built on two different blocks. The first is the ability of the computer to simulate situations that call for management decisions. The second block is a method that generates some guidelines that can simplify the way we look at an organization and direct us to better manage the simulated environment (in spite of the inherent complexity and prevailing uncertainty) and yet permit students to develop better guidelines as they learn. And so a realistic simulation must begin with a "theory" that can be tested by students before they try implementing anything in a real-world organization--to test, retest, think and rethink. This is what learning is all about.

DYNAMIC INTERACTIVE BUSINESS SIMULATIONS

Many businesses use interactive learning tools to teach their people how to perform a vast array of jobs and management activities. In particular, production-oriented firms employ business consulting firms and computer software providers to generate tailored operational and training software. A number of industrial educational organizations also provide specialized interactive computer simulations to teach a variety of management disciplines.

Virtually every industry has a vast array of dedicated computer software available for tasks such as production/operations management, accounting, financial analysis, project management, product design and market research. Many of these software programs include interactive training versions--simulations of operational applications on which students can test their knowledge, theories and skills. Several specialized organizations use interactive computer software to teach a variety of production/operations management techniques and apply modern theories of management in an academic environment. Among these are:

Technology Systems Corporation (TSC) of Bethlehem, Pennsylvania. TSC's *Management Interactive Case Study Simulator™ (MICSS)* is a powerful tool combining the range and simulation of the best business games with the more focused intensity of the case study. It primarily functions as an instrument for training and education in management strategy, and it can be also be used for enhancing skills in cooperative decision-making and for evaluating the capabilities of personnel to perform management tasks--especially the ability to think globally. *MICSS* simulates an entire industrial organization consisting of marketing, logistics, production, purchasing and finance departments. It carries a numerous scenarios, each emphasizing certain essential concepts of organizational environment, and is flexible enough to meet the criteria of many different educational programs. Thorough instruction manuals help management teachers learn how the simulators work and teach other to use them. (See Appendix A)

The Avraham Y. Goldratt Institute (AGI) in New Haven, Connecticut. AGI has spearheaded a nationwide interest in Constraints Management that has captured the attention of many industries and industrial organizations throughout the world. Among AGI's educational products is a series of interactive software simulations for learning to manage complex business organizations with effective decision-making tools. The Goldratt Institute provides its software and training to accredited colleges and universities without charge. (See Appendix B)

APICS--The Educational Society for Resource Management: With 70,000 members worldwide, APICS has local chapters and student chapters in most cities with considerable focus on interactive software training and education for member businesses. The transition from more complicated traditional process management techniques to the simple-but-effective system management tools of Constraints Management has become a major movement in this large national business group. In April, 1997, more than 500 academic and business leaders met in Denver, Colorado, for a two-day APICS symposium that included numerous demonstrations of interactive simulations and operational software for education and industry.

The American Society for Quality Control (ASQC) is a national business organization that operates a sizeable publishing branch, ASQC Quality Press. Several of its current published works include textbooks for academia that teach Theory of Constraints management tools; among these are two excellent books by H. William Dettmer, a recognized author of management texts and an educator who has spearheaded the use of interactive software at leading universities.

Goal Systems International (GSI), an industrial education and consulting consortium. GSI provides its own interactive simulation software for academic and business educational programs. GSI currently provides management education programs for several major corporations.

WHAT MAKES THEM INTERACTIVE?

Anyone can calculate the theoretical outcomes a system is capable of delivering. Interactive simulation programs enable teachers and students to examine a lot more than the static theoretical aspects of a system. Most textbooks and their floppy diskettes permit a **static** level of examination, but interactive software allows students to actually "run" simulations as **dynamic** systems and observe the effects of varying system parameters, measurements and policies. As students adjust specific parameters and reiterate the simulations in quick time, they engage in a learning experience that only one other activity can provide: real-world trial-and-error. (In the real world, however, such error is costly and usually unforgiven; at best, one gets one chance.)

Interactive computer simulators, like flight simulators, can be run repeatedly while changing selected parameters, permitting discovery of the cause-and-effect relationships within complex systems. Better still, the hardware is a lot less expensive than a flight simulator; in most cases these simulators can be run on existing personal computers. Students can repeat a process many times, at no physical or academic risk, and develop a genuine appreciation for the impact of different inputs, interactions and theories. In this role, interactive software behaves like a Socratic teacher; it presents questions that students answer by varying inputs and relationships in a realistic simulation and then shows them how their responses cause the system to function. When students observe the results, they make changes in their inputs and discover how real-world systems operate. Outcomes can be printed and used to assess homework and measure learning.

With a knowledgeable professor guiding their use of interactive simulators, students actually conduct deductive research and discover (or invent) better methods for making a real-world system achieve its goal. From this experience, they develop a much better understanding of the value of simple, elegant solutions that focus on the most critical factors in complex systems. The important difference in this learning method is that students learn which **few** factors cause most of the effects in complex systems. They discover that focusing on everything is, by definition, focusing on nothing.

A TYPICAL INTERACTIVE COMPUTER SIMULATION

Too often, researchers generate sophisticated mathematical models into which oceans of data are inserted. Many academic researchers conduct in-depth surveys and data collection, manipulate data in questionably-appropriate statistical models, and arrive at correlations between two or more factors without any idea of which are causes and which are effects, and which are significant and which are trivial. Unless they can separate the critical few from the trivial many, nothing useful is discovered. Interactive computer simulations provide an outstanding opportunity for students to avoid these pitfalls in a much shorter time frame while allowing repeated iterations of the process as earlier results suggest the need for additional analysis.

The best way to show how an interactive simulation program works is to simply set one up and run it. With the permission of the copyright owner, we will use one of their computer simulation programs to demonstrate their value as learning tools. The simulation chosen for this demonstration is a multidisciplinary program that incorporates many aspects of a product-based firm, including materials ordering and delivery, production scheduling and process flow, financial management, pricing and market demand. A complete demonstration takes about ten minutes.

SIMULATION TEN

The business simulation chosen for this demonstration is Simulation Ten (SIM 010), provided for academic use by the Avraham Y. Goldratt Institite (AGI). It involves a typical factory floor-plan consisting of eight production machines which manufacture three different products from four different types of raw material. This simulation is relatively simple. Materials costs, market prices and demand have been established, and yet traditional textbook linear programming techniques are unable to cope with the number of possible product mix permutations and the thousands of calculations needed to determine the ideal product mix (how many of each product to produce).

A first step for the student manager using this simulation is to determine exactly what product mix to use. Merely multiplying each product's demand by its selling price less materials costs is insufficient; it must first be determined that the plant's machines have the **capacity** to make all the quantities demanded. A static analysis of Simulation Ten quickly reveals that delivering all demanded items is beyond the capacity of one of the machines; this machine is clearly a **capacity-constrained resource.** A product mix decision will thus be needed to determine which products should be given priority at the **constraint** (constrained resource) while also determining how many of the other products to produce to optimize available constraint time and maximize profit. The simulator provides a simple-but-accurate measurement technique to enable the student to determine the priorities for production.

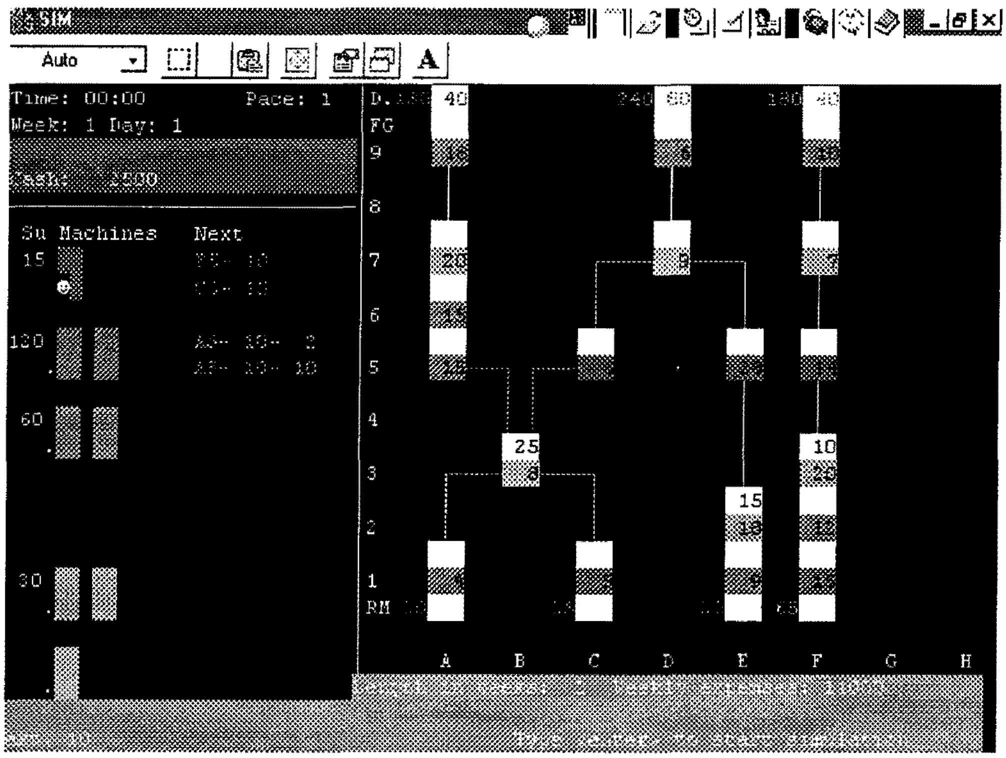

Fig 1: Floor Plan, SIM 010

A grid system is used to locate machines, materials and products. Users determine operating policies and enter commands to activate machines, order materials and schedule deliveries of finished products to the market.

USED WITH PERMISSION OF AGI

The students' first exposure to interactive computer simulation software is through lectures in which they learn how to use static measurements to calculate potential system performance. Without proper instruction, the simulators are not a complete learning tool. In a production business problem, students first learn how to calculate product mix, materials and machine schedules needed for ideal system financial performance outcomes (net profit, return on investment and cash flow). Initial efforts focus on determining whether the plant's equipment has the capacity to produce the quantities of each product demanded by the market. Paper copies of the simulation enable students to perform manual calculations of these parameters.

Analysis of Simulation Ten would reveal that the "blue" machine cannot meet market demand; it is clearly a capacity constrained resource (CCR). In fact, it is the **system constraint** because it is the greatest limitation to system goal achievement. All of the other machines have ample capacity to produce the demanded product mix, but it doesn't take a rocket scientist to realize that the entire plant is limited by how well the constraint meets demand. It is also easy to understand that *time lost at the constraint is time lost to the entire system; time saved at a nonconstraint is a mirage.*

Focusing on everything is, by definition, focusing on nothing. And so the student must learn to focus on the system constraint and ensure that it, the blue machine, is always running and producing products for the market. *"Do not starve the constraint!"* becomes the primary objective as students attempt to schedule materials purchases and activate all of the machines so as to provide a smooth flow from purchasing to finished goods.

When the Simulation Ten clock starts running, students assigned to each computer attempt via the keyboard to select purchase orders and manually schedule machine activations. Incidentally, this is the way many real-world firms still operate (the "hard way"), with various departments at cross purposes to each other and to the system's goal. Delays result in constraint starvation, while unnecessary (and costly) inventories develop in the wrong places. Expediting soon replaces firm schedules, finger pointing replaces coordination, and the system fails to reach its goal. In fact, most first efforts at manual scheduling result in simulated bankruptcy! There is a better way.

LEARNING TO DO IT THE SYSTEMS WAY

Once students understand why the manual efforts at Simulation Ten fail, the instructor can show them how to schedule the constraint machine for the entire simulation week. The constraint acts like the **"drummer"** in a marching band; it sets the pace for everything else. The students determine how many units the constraint will produce for each task, and on initial **"buffer"** inventories to protect the constraint from statistical variations in materials supplies and the machines that feed the constraint. The purchase of materials is then **"roped"** to supply the buffer's needs (not some contrived "economic" order quantity), providing the most timely release of materials into the factory. The **"drum-buffer-rope"** technique eliminates the need for hard scheduling of any of the other machines. Except at buffers, no inventories are needed to keep the process flowing, resulting in a "focused JIT approach" to manufacturing. Once the constraint schedule and buffers are set, the students only have to start the clock. If they decide to override the scheduled work, the students may activate machines at different locations and purchase materials for early delivery as they deem necessary.

OTHER SIMULATORS

Simulation ten is the base simulator for the series. Other simulators provide financial changes, market changes, production efficiency gains, quality problems, logistics and supply problems, machine breakdowns, and hundreds of other variations for the students to manage. Some simulators provide different plant layouts, distribution networks, market decisions and different problems to learn to solve. Most importantly, what students learn from these simulators is valid knowledge for managing a real-world business system. When students develop a good understanding of the management concepts practiced in one simulator, they may go on to other simulators to learn how to manage different problems and situations. With the guidance of the instructor, they learn to apply real management theory and process, obtain results in a relatively short time, and have new knowledge on which to base the in-class discussions that follow. Simulators are in no way replacements for good teachers; they depend on the ability of an instructor to teach the theories and methods that form the basis for every resource allocation and policy decision they make. Simulators are not video games; they're realistic simulations of real systems in which errors accumulate and are not simply excused by earning extra "lives."

THE DEMAND ALREADY EXISTS

Judging from the popularity of already-in-use interactive simulators in business and industry, the inclusion of suitable simulators in college courses will be well-received by the business world. It may come as a small shock to some academics, however, particularly those who have been comfortable for a long time using traditional classroom tools and methods. Colleges may find it useful to conduct in-house training for its faculty members. The simulators make sense and are easy to learn to use, and so academics are usually very comfortable with them. Some of the software producers provide excellent training manuals for this purpose. Altogether, interactive simulators combined with competent educators comprise a true technological advance in the art and science of teaching that cannot be matched by the "electronic college."

Simulation software is relatively inexpensive; in some cases, the producers allow free academic use. The Goldratt Institute provides free use of its simulators as well as free training for academics, while Technology Systems Corporation charges as little as $150 per course for a complete simulator package with manuals. The reason these products are inexpensive (or free) is that the software producers know that many of the students exposed to them in college programs will eventually want to use operational software in their professional activities--from the same producers. Businesses are already being exposed to these packages as sales representatives solicit new business from firms in a wide variety of industries. The aviation/aerospace industry is particularly adaptive to these new tools. In a nutshell, the demand already exists and is growing.

If demand for these products exists in the business world, then demand for learning how to use them exists in the academic world. The institutions that satisfy this demand will enhance their presence in the academic market because the content and quality and of their educational programs will improve. Relevance to student professional needs is a true measure of quality in education. Moreover, the responsiveness of the school's educational programs to changing real-world environments will also be enhanced. Ability to deliver timely educational products attracts new enrollments as employers realize their people can obtain professional education in accredited institutions.

INTERACTIVE SIMULATORS ARE VIRTUAL REALITY!

Interactive simulators for business and management courses can create a virtual reality of a small company, complete with shop floor, work centers, marketing, information systems, raw materials and suppliers--even a management team that makes decisions affecting the way the company runs. This small company also has built-in working rules and policies which students evaluate, select from, and configure to establish overall management performance characteristics of the company.

Every organization has rules and policies like this; rules that work--up to a point. Interactive simulators expose the students to these rules and policies on a much more comprehensive level than when addressed in the individual disciplines of traditional coursework. Once the students understand the working rules that govern the company, they should be able expand their learning experience by determining why these rules fail to satisfy company performance expectations, including matters of product quality, price and responsiveness.

Next, students can devise different rules and identify the problems these rules cause. Once can construct a logical tree to check the validity of the new rules. Interactive simulators allow students to change fundamental internal management rules and policies and then see what happens. In the real world, such learning is a very expensive endeavor, but within the simulation environment it is a simple, nonthreatening and fun exercise for both teacher and student. When this happens, the learning experience triggers something even more valuable: understanding.

IMPROVED ACADEMIC PROGRAMS--A NECESSARY CONDITION FOR SURVIVAL

When students understand how to examine the effects of changing rules and policies, they learn how to analyze real-world organizations in a process of ongoing improvement. They realize that improvement can never stop, and that there is never an “optimal state” for an organization in the world of global and continually evolving competition. Continuous improvement is a necessary condition for business; it is also a necessary condition for higher education.

Amid all the technological advances being introduced into the college classroom today, only one--interactive computer simulators--offers a more realistic view of the real world about which students wish to learn. Interactive simulation is also a learning tool that will improve the relevance of higher education to the needs of students and their employers, and thereby attract new students to formal institutions of higher learning who would otherwise be considering other schools and other learning media.

Melvin J Anderson, Ph.D. May, 1997

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APPENDIX A

Technology Systems Corporation: MICSS interactive simulator

TSC's Management Interactive Case Study Simulators (MICSS) provide a series of computerized environments for learning. Each is a simulation of a complex business environment, including its aspect for uncertainty. MICSS enables students to dictate the managerial issues for running a complete company. The semi-complex demo version of MICSS depicts a "Simple Company" that has two products, four machines and three raw materials. Screens show four "views" of this company-- marketing, production, purchasing and finance--with click-on breakouts of the details of each view. The simulations are highly interactive.

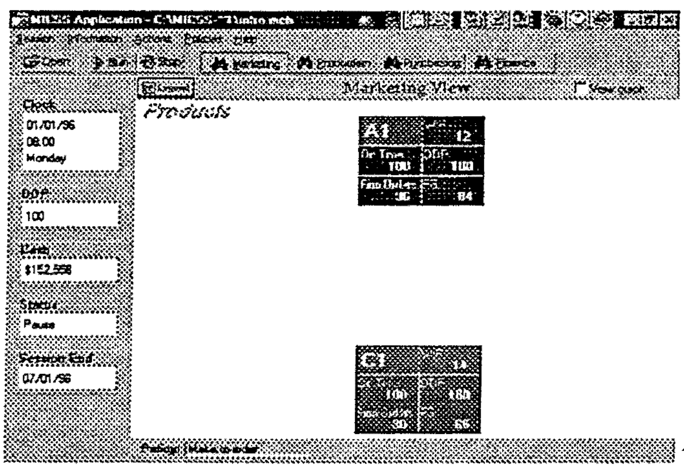

Fig A-1: Marketing View.
Students can determine and track market measurements for each product as their "Simple Company" attempts to maximize profits.

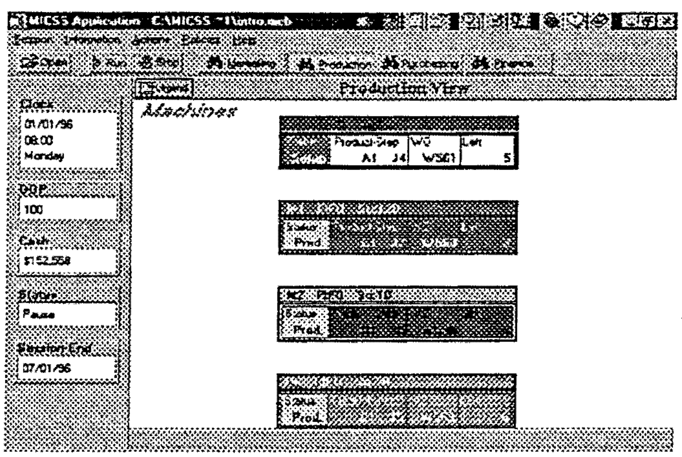

Fig A-2: Production View.
Students can "click on" each of the four machines to determine production activities, select different scheduling parameters and track system performance.

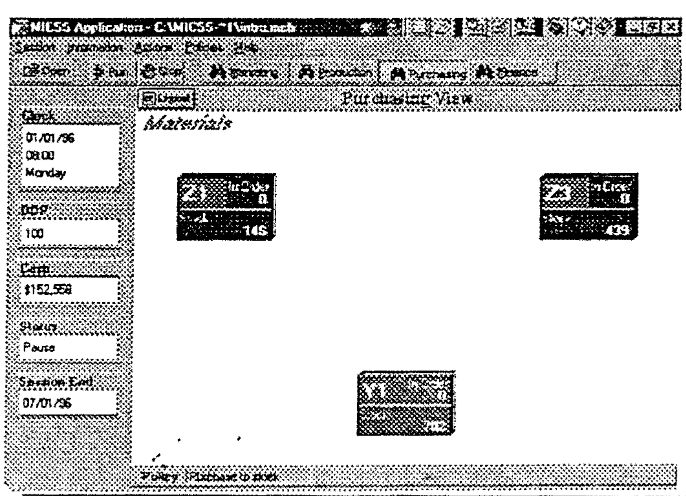

Fig A-3: Purchasing View.
Students can determine purchasing policies to support system goals, make purchases as needed and observe system impact.

By coordinating all four views, students learn how to plan, schedule and control all the aspects of a small business.

(The financial view is a detailed operating statement and balance sheet.)

APPENDIX B
Avraham Y. Goldratt Institute (AGI): Functional Effectiveness Workshop Simulators

AGI simulators cover a wide spectrum of management disciplines. Two different types of simulator are shown.

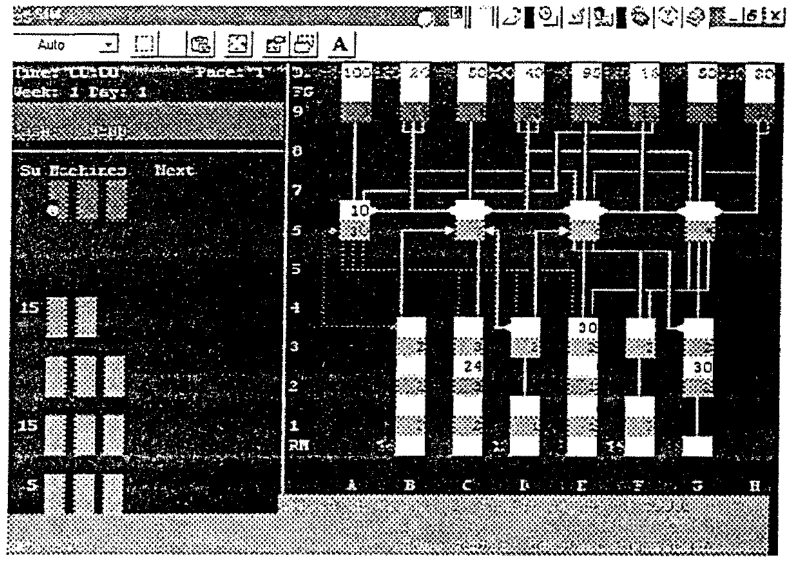

Fig B-1:
V-Plant Production Simulator 300

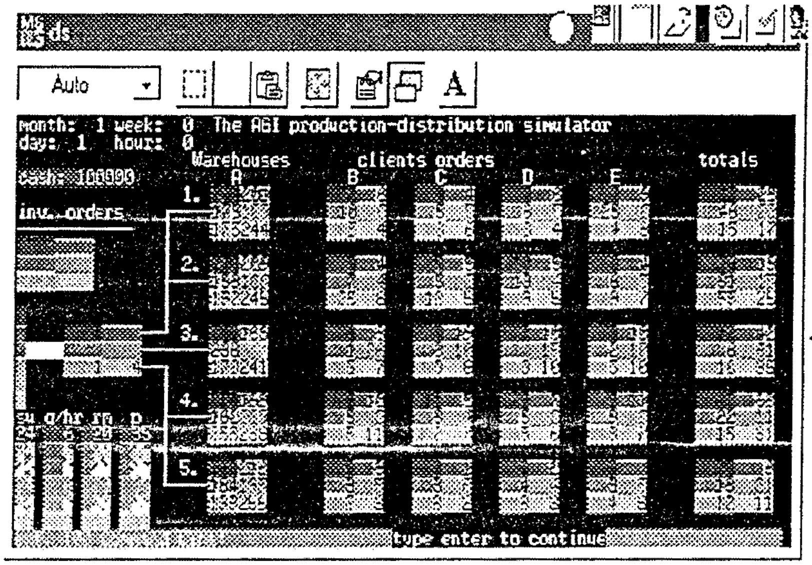

Fig B-2:
Distribution Simulator 100 Distribution Network.
This screen shows the flow of finished goods from production to warehouses and clients. Students can establish distribution plans and policies, observe flow and make adjustments as they discover how their theories and methods work.

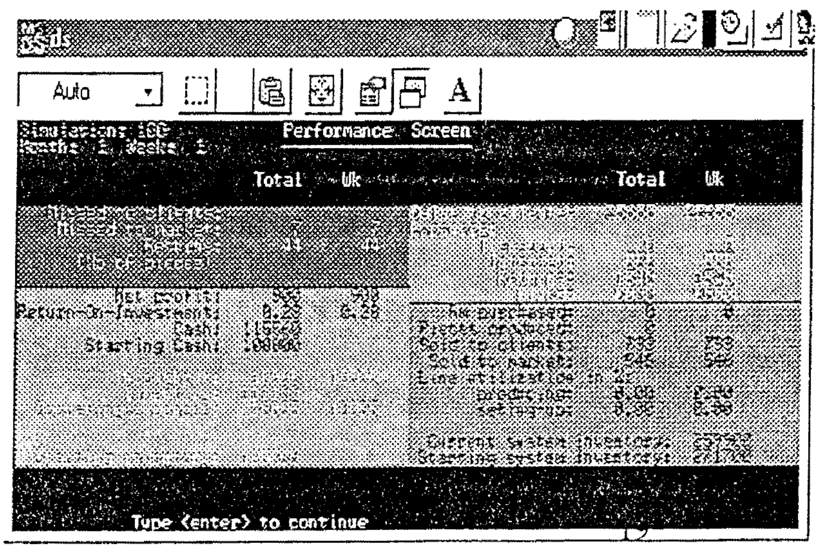

Fig B-3:
Distribution Simulator 100 Performance Screen.
Screen shows a running total of system performance as the simulated "week" continues.

USED WITH PERMISSION OF AGI